AN EXAMINATION OF INFORMATION TECHNOLOGY VALUATION MODELS FOR THE AIR FORCE

THESIS

Todd A. Peachey, Captain, USAF

AFIT/GIR/LAL/98S-10

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GIR/LAL/98S-10

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Todd A. Peachey, B.S.

Captain, USAF

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Abstract

Information technology investment has become a significant part of the Department of Defense's budget. The Information Technology Management Reform Act requires that government quantitatively evaluate future information technology investments. Quantitative evaluation of IT investments present special problems for agencies that do not generate incoming cash flows.

This thesis is designed to examine models that are currently being used in the public and private sector of the economy to evaluate Information Technology investments to learn which ones might serve the needs of the United States Air Force. The methodology is an exploratory study based on Criterion-based Congruence Analysis. This technique is designed to collect information and then filter it to surface the information that is pertinent to the research question.

This research uncovered 18 models that use a variety of methods to value information technology. Of these models, five could currently be used by the Air Force based on the availability of the required data. These models are: Cost Benefit Analysis, Cost of Information Management, IT Spending, Residual Value, and the Balanced Scorecard. There are two additional models that may contribute to investment decisions in very specific circumstances. These models are: Business Profitability, and Information Productivity.

AN EXAMINATION OF INFORMATION TECHNOLOGY VALUATION MODELS FOR THE AIR FORCE

I. Introduction

Background

Since the late 1960s, private industry and government has invested and continues to invest a significant quantity of money in information technology (IT). Estimates for worldwide annual spending on computers and associated products are over $1 trillion annually with the United States' share of this spending over $500 billion (Strassmann, 1997:26). There are high expectations for increases in productivity and profitability associated with these investments. Taxpayers and stockholders both have the right to expect the substantial investments in IT to have positive effects on the operations of the entity. In the manufacturing sector, productivity increases have been significant, however, these increases have not been seen in the service sector (Brynjolfsson, 1993:68). Government, which is primarily a service based organization, has also not shown the expected productivity increases from substantial investments in IT. "Despite spending more than $200 Billion on information management and systems, the government has too little evidence of meaningful returns" (United States Government Accounting Office, 1994:5). One example of this is the Department of Defense's (DoD) experience with Ada. "As a result of the investment in Ada,

the DoD now possesses code that is expensive to maintain" (Strassmann, 1997:148).

In 1996, the Information Technology Management Reform Act (ITMRA) tasked the Federal Government and all subordinate agencies, including the Department of Defense (DoD), to quantitatively justify their investments in IT (U.S. Congress, 1996: Section 5122 b 5).

The ITMRA is the driving force behind this project. This law directs the government to better evaluate its IT investments and is a broad directive on how information and IT investment should be handled by the government. Specifically, in Section 5122, paragraph b3, the ITMRA requires that minimum criteria related to quantifiably expressed project net value, risk adjusted ROI, and prioritzability of projects be applied to any new IT investments. In Section 5122 (b) 5 of the ITMRA, which provides one of the bases for this research, agencies are also tasked with identifying other quantifiable techniques for evaluation.

The Federal Government has two unique problems it must solve to meet the intent of the ITMRA. Government entities operate in a environment vastly different from private enterprises. Most government organizations are funded through budgets and do not face the constraint of generating cash flows from operations to justify new IT investment.

As the literature review will show, many of the currently available models that measure IT valuation are based on revenue generation. This causes significant difficulty in applying these models to organizations such as the DoD

where incoming cash flows from operations are non-existent. Other variables embedded in the model may also require information that is not available. This leads to the problem of whether or not the data is available for each model.

IT investment is very difficult to evaluate when there are revenue exchanges. This problem is exacerbated when there are no revenue flows to base the valuation on, such as in a government entity. The problems are also compounded by using contemporary methods of asset valuation and productivity measures because of the unique capabilities and opportunities IT provides.

The second problem is that there are no productivity measures that adequately quantify IT productivity at the firm level. Noted IT researcher and practitioner Strassmann noted the problems associated with measuring IT productivity by describing the results of a study by the National Research Council in relation to research by Brynjolfsson and Hitt (Strassmann, 1997:95-96). Fortune (Magnet, 1994:79), and Business Week (Gleckman et al, 1993:56), proclaimed that studies by Brynjolfsson and Hitt had finally proven the productivity of computers. However, at the same time, the National Research Council published a study that concluded that "during the 1980's, the service sector showed limited gains in productivity despite and extraordinary burst of spending on IT" (National Research Council, 1994:5).

To summarize one of their research efforts, Hitt and Brynjolfsson concluded that "while IT has been productive for the average firm, many firms undoubtedly made unproductive investments in IT" (Hitt and Brynjolfsson,

1996:136). This statement suggests that organizations haven't yet been able to differentiate which IT investments lead to increased productivity and what specific factors drive increased productivity.

There has been a significant amount of research in the areas of IT valuation and productivity, but the majority of research is still based mainly on theory and has not been extensively tested at the organizational level. As budgets continue to be cut, the government must find better ways to evaluate its investments in IT.

Researchers and practitioners have suggested that organizations are not receiving as many benefits as they should from the investment in IT. This is what led to the ITMRA requiring quantitative evaluation of the risks and benefits of IT investment.

Office productivity has been stagnant in the last several years while investment in IT has been increasing substantially (Panko, 1991:199). Panko observed that this has profound implications for researchers and practitioners. Part of the problem with this data is how we measure productivity. The Bureau of Labor Statistics (BLS) does not currently collect data for office productivity because of the difficulties with measurement. The majority of data that BLS analyzes is based on single factors of production such as a units of output per units of labor, or units of output per unit of capital. Office productivity does not lend itself well to such measures.

Multi-factor models, such as the capital-labor multifactor productivity model and the KLEMS (capital, labor, energy, materials, and outside services) multifactor productivity model, currently used in the manufacturing sector, would better measure office productivity (Panko, 1991:196). However, even this may not solve the measurement problem. The problem is not how much we invest in IT, but how we use IT (Panko, 1991:199).

IT investment should not be blamed for the stagnant growth in productivity for two reasons. The first reasons is that

> productivity is difficult to measure in general and office output per hour can only be measured with some validity in industries where the percentage of office workers in the work force is very high and where output measurement problems are low. (Panko, 1991:200)

The second reason for the problem is that "while IT is certainly large in relative terms, it accounts for a small portion of all office spending," (Panko, 1991:200).

Another review of corporate performance is provided in the article "Measuring Corporate Performance" by Brown and Laverick. Their conclusion was that standard corporate performance measures are often not adequate to describe the success of an organization. In particular, the authors discussed standard accounting measures while describing the shortcomings of each measure. The authors noted when "serious conflicts arise in an organization, it is inevitable that financial considerations override all other alternatives" (Brown and Laverick, 1994:96). Additionally, the authors posited that "instead of

yesterday's performance measuring yesterday's decisions, what are needed are measures that provide today's decisions, which will benefit tomorrow's performance" (Brown and Laverick, 1994:96). This conclusion directly supports the idea that we must find a new model that better describes the effect that today's decisions will have on future performance.

Problem Statement

How can the Air Force comply with the ITMRA with respect to:

1. Paragraph 5112 (c) – "include explicit criteria for analyzing the projected and actual costs, benefits, and risks associated with the investments"
2. Paragraph 5122 (b) 5 – "provide for identifying for a proposed investment quantifiable measures for determining the net benefits and risks of the investment"

Research Objectives

To solve this problem there are three steps that the Air Force must accomplish:

1. Identify possible IT investment evaluation models
2. Identify which models meet the intent of the ITMRA
3. Identify which models are feasible

Research Questions

The objectives listed above can be reduced to the following two questions:

1. What models are currently being used in the DoD and private industry to evaluate their investment in information technology?
2. Of these models, which ones can the Air Force use to evaluate potential investment in IT with respect to the ITMRA and with regard to the availability of the required data?

Scope

The research for this thesis will have a broad scope by necessity to search for any models that may be applicable to the DoD. This search will include practitioner journals, academic journals, textbooks, and any information available through the internet.

Management Implications

As budgets continue to fall, or at least stabilize, the Air Force must receive more value from its IT investments. As the military moves towards dramatically reducing its support structure to invest more in weapons systems and modernization, IT is an area that can provide some of the productivity and efficiency gains that the military needs. IT is one of the largest areas of investment in support equipment. The military, and government in general, must ensure that its investment in support equipment are absolutely the most it can

receive for its money. By properly managing the investments in IT the Air Force can avoid mistakes of the past such as the DoD's problems with Ada that were alluded to earlier. As research in this area improves and better techniques are developed for IT investment valuation, the opportunity to get the most from our investments will improve.

Overview

Chapter II consists of a review of the pertinent academic and practitioner literature on this topic. The chapter will address literature that describes current DoD policy, productivity concepts, and models for valuation of IT investment. Chapter II will also describe any models that are uncovered by the research.

Chapter III describes the methodology for this research. The methodology is based on Criterion-based Congruence Analysis, Miles and Huberman's qualitative research techniques, Cooper and Emory's data collection methods, and a Delphi group for variable validation. The models described in Chapter II require different variables to quantify IT investment valuation. The concept of variable validation is based on whether or not the data for these variables is available.

Chapter IV will describe the results of the Delphi panel, which will determine the models that may be useful for the Air Force.

Chapter V contains a discussion of results and the conclusions regarding the usefulness of the models based on the variable validation. Chapter V will

close with a discussion of the implications of this research for the Air Force, and recommendations for future research.

II. Literature Review

Introduction

This literature review examines the current body of knowledge in the area of IT investment valuation. For the purpose of this literature review, IT investment will be defined as hardware, software, and infrastructure components such as routers, hubs and cabling, in addition to other expenses related to IT such as training and maintenance. This review will focus on how public and private sector firms evaluate their investments in IT as described in academic and trade literature.

Types of Models

In one effort to examine IT investment valuation models, nine objective and eight subjective models that are currently used by firms to evaluate their investments were examined (Powell, 1992:30). These models use a wide range of criteria that is readily available to most organizations and apply different techniques such questionnaires, probabilities, operational performance parameters, and financial data analysis. Powell aggregated the views of many practitioners in the field and stated "most are of one opinion, that the costs and benefits associated with computer systems are difficult to quantify" (Powell, 1992:30).

After brief examination of the models, Powell offered that "these standard techniques do not appear to be widely used, even though they have been employed in other fields and are recognized as useful" (Powell, 1992:40). One minor problem with Powell's research was that several of the concepts were extended series of guidelines for how to manage IT and not models for assessing its value.

The next section discusses the models discovered during the research. The models are classified into four categories: accounting models , options models, economic models, and miscellaneous models. These categories are simply a logical presentation of different models recommended by IT researchers and practitioners.

<u>Accounting Models</u>. The first category is the Accounting Models. These models are the basis for capital investment by organizations. They include such standard concepts as Return on Investment (ROI), Payback (PB), and Net Present Value (NPV). Return on Investment (ROI) is a key factor used by private sector firms to evaluate any capital investment. "Time for a Fresh Approach to ROI" describes several reasons why typical ROI approaches are not adequate for evaluating IT investments (Moad, 1995:57). ROI doesn't account for some of the unique capabilities of IT. Moad prescribed a model under development by John Henderson of Boston University based on Contingent Claims Theory (Moad, 1995:57). This model takes theory from options pricing

and suggests a new way to evaluate IT that provides decision makers with other ways to look at how they manage IT.

One author who applied standard accounting techniques to IT investment valuation was Senn in his textbook Information Systems in Management. Senn gave a brief description of Net Present Value (NPV) and Payback (PB), (Senn, 1978:523-524). Even in this early examination of traditional accounting methods, Senn noted that "the intangible benefits are ignored, even though they may be the most important ones for the project" (Senn, 1978:525). The model for NPV is shown in equation 1 (Dos Santos, 1991:74, Senn, 1978:523).

$$= - C_0 + \sum (t=1 \text{ to } T)\ A_t / (1+r)^t \qquad (1)$$

where C_0 is the net investment cash outflow, T is the project life, A_t is the cash inflow at time period t, and r is the cost of capital

The model for Payback is shown in equation 2 (Senn, 1978:525).

$$= \text{total income / total time horizon} \qquad (2)$$

Another accounting technique is Cost-Benefit Analysis (Kurnia and Swatman, 1997). Kurnia and Swatman expanded on the standard cost benefit analysis to specifically address areas of IT investment. One particular benefit of this work was the authors' adaptation of the model specifically for use in the public sector (Kurnia and Swatman, 1997:5). The model uses variables specific to IT investment that are readily quantifiable. The first year model is as follows: First Year (Kurnia and Swatman, 1997:5).

$$\text{Actual Costs} = \text{Total Costs} - \text{Total Benefits} \qquad (3)$$

where Total Costs = Hardware Costs + Software Costs + Transmission Costs + Membership Costs, and Total Benefits = Processing Cost Savings + Paper Savings + Inventory Savings + Quantifiable Intangible Benefits

The issues relating to subsequent year's investment were also addressed. (Kurnia and Swatman, 1997:6). The subsequent year model is as follows:

Subsequent Years (Kurnia, 1997:6).

$$\text{Actual Costs} = \text{On-going Costs} - \text{On going Benefits} \qquad (4)$$

where On-going Costs = Transmission Costs + Software Management + Fixed Annual Costs, and On-going Savings = Processing Cost Savings + Paper Savings + Inventory Savings + Quantifiable Intangible Benefits

One of the first researchers to notice the problems with traditional accounting methods in evaluating IT investments was Peter Lay (1985:32). After describing Cost-benefit Analysis briefly, Lay examined the intangible benefits that IT investment provides. In particular he suggested that some systems "may provide ONLY intangible benefits" (Lay, 1985:32). Lay also examined other factors where traditional evaluation may be somewhat misleading. Many costs of IT investment cannot be accurately quantified before initiation of the project. Often these costs, such as software development, are often inaccurately estimated. With the speed of change and the complexity that the technology of information systems changes, it's easy to see how estimation of costs on a major project can be dramatically different than originally estimated. Lay points out that the most serious drawback of cost/benefit analysis is that it is a "rigid tool that cannot bend to the strategy of the organization" (Lay, 1985:35).

One examination of valuation techniques compared standard financial methods such as Discounted Cash Flow (DCF) and NPV to an options valuation model (Dos Santos, 1991:71). The key question Dos Santos wanted a model to answer was "Is investment in the new technology justified?" (Dos Santos, 1991:72).

After a brief evaluation of the financial techniques, Dos Santos concluded that "traditional financial analysis is neither recommended nor used because it does not adequately deal with the real value of these projects" (Dos Santos, 1991:72) . This conclusion led to the consideration of other valuation techniques that may be able to better quantify the unique capabilities of IT. A model that may better quantify IT investment is based on options pricing theory.

Options Models. The next category is the Options Models. Several researchers have discussed using options valuation techniques as a way to improve the IT investment process. Moad described three types of information that the Options Model adds to IT investment analysis: they are "current and possible future business strategies, systems capabilities the firm may want in the future, and risks and costs of various IT currently used by the firm" (Moad, 1995:58). While all this data may not apply specifically to DoD, it does provide some interesting insights into how better to evaluate IT investments. Moad's primary finding was that the Options Model should not be used as a replacement for ROI but can add more valuable information to the decision (Moad, 1995:58).

The options pricing model was originally developed by Margrabe to price an option to exchange one risky asset for another (Margrabe, 1978:181). Dos Santos used this model to price an option (a decision) "to undertake a future project" (Dos Santos, 1991:80). One of the main problems with this model is the requirement to estimate future variables required by the model such as the correlation between the development costs and revenues for the second stage project and the variance of the rate of change of development costs of the second stage project (Dos Santos, 1991:82). The accuracy of these estimates could dramatically effect the information provided to the decision maker.

This model places value on managerial flexibility by considering the alternatives that may be available in the future. However, Dos Santos closed this article by noting that "methods aimed at obtaining accurate estimates of the parameters needed to use this model will need to be developed" (Dos Santos, 1991:87). This model has not been tested extensively in organizations but has interesting implications as further research is conducted.

Ram Kumar further explored the applicability of options pricing models (Kumar, 1996:189). Kumar summarizes two major approaches to options valuation, the Black-Scholes model, and the Margrabe model. The research examined one example and concluded that option valuation techniques would add to the decision if "riskier projects increase or decrease values for a particular scenario" (Kumar 1996:192). The model for Options Pricing is shown in equation 5 (Kumar, 1996:188, Dos Santos, 1991:81).

$$V = B_1N(d_1)-C_1N(d_2) \qquad (5)$$

where $d_1 = (\ln(B_1/C_1) + \frac{1}{2}\sigma^2 t) / \sigma t^{1/2}$, $d_2 = d_1 - \sigma t^{1/2}$, V = Value of Option, C = expected value of asset, B = expected return on asset, t = time to expiration, N = standard normal density function, σ = standard deviations of rate of change between B and C

While this article shows a solid example of how the options models can contribute to IT investment decisions, there are still the problems described in the review of Dos Santos' work, that of estimation of several variables.

Two more recent articles explored the idea of an options approach to capital investment. These articles focus on capital investment in assets that are easier to measure than IT, however some of the principles may provide insight into how to use this method to better quantify IT investment (Dixit and Pindyck, 1995:105). Dixit and Pindyck examined the problems with standard approaches to capital investment valuation. The authors posited that the standard Net Present Value (NPV) technique does not include all pertinent information when making a decision about capital investment. Three scenarios were examined, to include investment in oil reserves, electric utilities, and commodity price volatility. In these three scenarios, the options technique offered decision makers a way to quantify the value of flexibility in delaying decisions. The authors concluded that "options create flexibility, and, in an uncertain world, the ability to value and to use flexibility is crucial" (Dixit and Pindyck, 1995:115).

Smith and Nau also examined three different approaches: risk-adjusted discount-rate analysis, option pricing analysis, and decision analysis (Smith and Nau, 1995:795). The authors used a capital budgeting example to show how option pricing analysis and decision analysis can be integrated to improve the information for the decision makers. The authors concluded that option pricing and decision analysis are compatible in their results and can be profitably integrated (Smith and Nau, 1995:812-813).

In another attempt to add an additional factor to IT valuation, Kumar addressed how options can be used to quantify the flexibility or responsiveness that IT investment gives the corporation (Kumar, 1998:1). IT investment, because of its applicability to many different functions, gives the organization flexibility to change focus as the project is in progress. This model is different from earlier work by Dos Santos. Dos Santos looked specifically at the value added by an option to make changes to the project by a specific date. In this model, Kumar uses a model originally proposed by Majd and Pindyck that values sequential investment opportunities but does not force the subsequent investments to be made by a certain date. In the private sector, profits and ROI calculations can provide some insight into how well IT is managed. However, in government, these techniques do not apply well because of their reliance on income as a variable. Productivity may be one method for evaluating IT for government use.

Economic Models. The third category is the Economic Models. These models are based in economic theory such as consumer surplus and the production function. While relying heavily on economic theory, the models presented in this paper have been initially tested by the original authors.

Brynjolfsson, who has researched extensively in the field of IT productivity, reviewed the paradox of why productivity has not been shown to have grown while there have been significant investments in IT over the past 30 years (Brynjolfsson, 1993:68). Brynjolfsson then suggested several reasons for this phenomena. The first is that organizations do not measure the correct outputs and inputs. The second is the lags in learning that are inherent in the move to new systems. Next is the redistribution and dissipation of profits. Finally, the author suggested that there is significant mismanagement of information and technology (Brynjolfsson, 1993:73).

Since the government cannot use profitability measures to guide IT investment, productivity measures would be one area where it could quantify savings. However, as noted by Brynjolfsson, researchers do not yet have a strong grasp on the relationship between IT investment and increased productivity (Brynjolfsson, 193:76).

Wurth discussed the standard definition of productivity as the change in outputs divided by the change in inputs (Wurth, 1993:233). This definition is standard in economic theory and provides the basis from which this research must start. The author noted an important concept that future research must

consider; the concept that significant gains are normally achieved when there are qualitative change in processes and not quantitative changes in inputs.

One of the key articles in IT investment theory looks at three different measures of IT investment; Productivity, Profitability, and Consumer Surplus (Hitt and Brynjolfsson, 1996:121). The authors offer an interesting perspective by considering productivity and consumer surplus in addition to the more common measure, profitability.

Consumer surplus provides interesting implications for use with government. Consumer surplus is a concept of value that quantifies the value passed on to consumers from investments in IT. Within the government, consumers could be considered as internal and external customers. The model for Consumer Surplus is shown in equation 6 (Hitt and Brynjolfsson, 1996:135).

$$\text{Surplus}_{t+1} = \tfrac{1}{2}\,(S_{t+1} + S_t) * \log\,(p_t / p_{t+1}) * V \qquad (6)$$

where t = time period, S = IT Stock to Value Added, P = Price of IT Stock, V=Value Added

Productivity is also a measure that can be applied more easily to government organizations. The model (the Cobb-Douglas production function) employed by Hitt and Brynjolfsson had variables that considered IT stock, non-computer capital, and labor. The regression equation used to estimate the Value Added showed extremely positive results across all tests. The model for the Production Function Approach is shown in equation 7 (Hitt and Brynjolfsson, 1996:130).

$$V = \exp\left(\Sigma_t D_t + \Sigma_{j\text{-}1} D_j\right) C^{\beta 1} K^{\beta 2} L^{\beta 3} \qquad (7)$$

where C = Total IT Stock, K = Non-Computer Capital, L = Labor, V = Value Added, D = Dummy variable to control for year, β = output elasticity of IT stock (% change in output / 1% increase in IT Stock)

Profitability has its foundations in the common measures of Return on Assets (ROA), Return on Investment (ROI), and Shareholder Return. These areas provide key measures of how well a business uses its capital, however, these measures are not easily applied to nonprofit government organizations. The model for Business Profitability Analysis is shown in equation 8 (Hitt and Brynjolfsson, 1996:132).

$$\text{Profitability Ratio} = \alpha_0 + \alpha_1 * (\text{ITRate}) + \text{control variables} + \varepsilon \quad (8)$$

where ITRate = ratio of IT stock to firm employees, α is a constant

In addition to the work of Brynjolfsson and Hitt, others have applied pure economic theory to IT investment. Bakos and Kemerer looked at different economic theories and how they might be applied to IT valuation (Bakos and Kemerer, 1992:365). The authors first described the economic characteristics of IT. Then, the authors discussed several economic theories describing the current applications and then offered ideas for future research in the specific areas. The authors main conclusion was that "the benefits are present, but simply not being measured correctly with current approaches" (Bakos and Kemerer, 1992:380). The economic models described above examine different areas where IT investment effects an organization. Other models, such as those

discussed in the next section, explore what effects IT has on the management of the organization.

Miscellaneous Models. The final category is the Miscellaneous Models. These models are often more subjective in nature and at some point may rely on subjective measures of performance.

Strassmann suggested "one area to address in order to increase productivity is information management" (Strassmann, 1998a). Information management can be defined as the cost of "all information processes, not just those which involve IT" (Strassmann, 1998a). The model for the Cost of Information Management is shown in equation 9 (Strassmann, 1998a).

$$= \text{Cost of Sales, General and Administrative} + \text{Cost of Research and Development} \tag{9}$$

Strassmann found that "over 80% of US organizations invest more on information than on capital" (Strassmann, 1998a). The model for the Cost of Capital is shown in equation 10 (Strassmann, 1998a).

$$= (\text{Shareholder Equity} + \text{Capital Surplus}) * \text{Interest Rate} \tag{10}$$

Information Productivity is another area that Strassmann examined. "The exploration of information productivity is necessary because even a favorable evaluation of computer expenditures offers no guarantee of competitive viability" (Strassmann, 1997:xviii). The model for Information Productivity, Private Sector is shown in equation 11 (Strassmann, 1998a).

= Value Added by Information (11)
/ Cost of Information Management

To calculate the value of Information Productivity, an organization must first calculate the Value Added by Information. To calculate the value added Strassmann suggests that "capital is a commodity, and deducts the cost of paying rent on it" (Strassmann, 1998a). The model for Value Added by Information is shown in equation 12 (Strassmann, 1998a).

= Net Profit – (Financial Capital Assets (12)
* Interest Rate for Borrowing)

Strassmann also developed a model of Information Productivity for the public sector which "doesn't take account of revenue and capital in the same way" (Strassmann, 1998a). The model for Information Productivity, Public Sector is shown in equation 13 (Strassmann, 1998a).

= Cost of Operations (13)
/ Cost of Information Management

Strassmann stated that there is "no direct link between IT spending and productivity" (Strassmann, 1998a). "A CIO needs to be able to compare IT expenditure with that of competitors...it is also useful to compare divisions within an organization" (Strassmann, 1998a). The model for IT Spending is shown in equation 14 (Strassmann, 1998a).

= a + b*(Cost of Sales, General, and Administrative) (14)
+ c*Profits + D*Desktops + e*Professionals – f*Executives

Strassmann stated that "the wealth of an organization is based on its accumulation of useful knowledge – its knowledge capital" (Strassmann, 1998a). The model for Knowledge Capital is shown in equation 15 (Strassmann, 1998a).

$$= \text{Value Added by Information} \;/\; \text{Interest Rate for Equity Capital} \tag{15}$$

Strassmann posited that "for all practical purposes, the existing approach to valuing IT assets is useless except as a way of complying with regulatory and taxation purposes" (Strassmann, 1997:337). Information is different from other assets and should be managed differently. One key suggestion for successful IT management is to "include the residual value of a project in all project payoff calculations" (Strassmann, 1997:335). The model for the Residual Value Formula is shown in equation 16 (Strassmann, 1997:337).

$$\begin{aligned} &= \text{Change in Information Technology Assets} = (\text{equipment acquisition} \\ &\quad - \text{equipment depreciation}) + (\text{development acquisition} \\ &\quad - \text{development depreciation}) + (\text{software acquisition} \\ &\quad - \text{software depreciation}) + (\text{training acquisition} - \text{training depreciation}) \end{aligned} \tag{16}$$

Another attempt to quantify Knowledge Capital lead to replacement of The Value Added by Information (equation 12, 15) model with the Management Value Added model (Strassmann, 1998b). Strassmann defines Management Value Added as "what is left over after absolutely all costs are fully accounted for" (Strassmann, 1998b). The revised model for Knowledge Capital is shown in equation 17 (Strassmann, 1998b).

$$= \text{Management Value Added} / \text{Price of Capital} \quad (17)$$

In 1992, Robert Kaplan and David Norton developed a method called the Balanced Scorecard to present executives with information in a manner that directly relates the information to specific goals within the company in four areas: the financial perspective, the customer perspective, the internal business perspective, and the innovation and learning perspective (Kaplan and Norton, 1992:72). This technique was developed after a "year long research project with 12 companies at the leading edge of performance measurement" (Kaplan and Norton, 1992:71). The Balanced Scorecard is designed to put "strategy, not control" at the center of performance management (Kaplan and Norton 1992:79). The authors posited that this new approach is consistent with many current management trends including team focus, cross-functional integration, and customer-supplier partnerships. The Balanced Scorecard was tested in a later article on specific companies including Apple computer and Advanced Micro Devices (Kaplan and Norton, 1993:140-141). In a final article, Kaplan and Norton further refined the use of this technique for businesses (Kaplan and Norton, 1996:75). The key point in this article was how companies could use the Balanced Scorecard to align management processes and focus the entire organization on implementing its long-term strategy (Kaplan and Norton, 1996:85).

Also in 1996, Kaplan and Norton published a book, The Balanced Scorecard, that further explained the applications of their model, in particular, how public organizations could apply the financial measures (Kaplan and Norton, 1996: 179). One of the key problems with IT investment valuation in public organizations is how to consider the budget. Kaplan and Norton note that meeting a budget is not a success if the customer loses service or if the mission of the agency is compromised. The authors note that tangible objectives must be defined for customers and that financial considerations can play an enabling or constraining role but will rarely be the primary objective (Kaplan and Norton, 1996:180). The balanced scorecard is a technique that focuses on managing a large business, so how does the balanced scorecard fit in with IT valuation?

Van Grembergen and Van Bruggen applied the balanced scorecard to the valuation of IT investments (Van Grembergen and Van Bruggen, 1998:1). The authors changed the basic areas of the Balanced Scorecard, the financial perspective, the customer perspective, the internal business perspective, and the innovation and learning perspective, into areas specific to the IT function within a business: user orientation, corporate contribution, operational excellence, and future orientation (Van Grembergen and Van Bruggen, 1998:2). These areas are further broken down in to specific mission and objective statements. Additionally, the authors suggested outcome and performance measures for each area. The majority of these measures are quantifiable so that they could be tracked in relation to goal attainment.

Van Grembergen and Van Bruggen proposed this technique, composed of elements of "information economics and business reengineering" (Van Grembergen and Van Bruggen, 1998:7), as a model that addresses both readily quantifiable variables and more abstract measures of user satisfaction as an overall management tool for IT. The authors have not tested this model with any organizations.

The Balanced Scorecard is shown in Tables 1 through 5 (Van Grembergen and Van Bruggen, 1998:9-11). Table 1 shows the Balanced Scorecard for IT. This table focuses on the key contributions of IT for organizations. Table 1 is divided into four key areas: User Orientation, Corporate Contribution, Operational Excellence, and Future Orientation (Van Grembergen and Van Bruggen, 1998). These four areas are further reduced into their respective mission statements and specific objectives.

Table 1. The Balanced Scorecard

User Orientation How do the users view the IT Department?	Corporate Contribution How does management view the IT Department?
Mission To be the preferred supplier of information systems and to exploit business opportunities maximally through information technology Objectives • preferred supplier of applications • preferred supplier of operations • partnership with users • user-satisfaction	Mission To obtain a reasonable business contribution of investments in IT Objectives • control of IT expenses • sell IT products and services to third parties • business value of new IT projects • business value of IT function
Operational Excellence How effective and efficient are the IT processes?	Future Orientation Is IT positioned to meet future challenges?
Mission Efficiently deliver IT products and services Objectives • efficient software development • efficient operations • acquisition of PCs and PC-software • problem management • training users • management of IT personnel • use of communications software	Mission Develop opportunities to answer future challenges Objectives • permanent training and education of IT personnel • expertise of IT personnel • age of the applications software • research into emerging information technologies

Table 2 shows the specific variables for the subcomponet of Corporate Contribution. The four proposed measures are: Control IT Expenses, Sell to Third Parties, Business Value of New IT Projects, and Business Value of IT Function (Van Grembergen and Van Bruggen, 1998).

Table 2. Measures for Corporate Contribution

Control IT Expenses
• percentage above or within IT budget • allocation of the different budget items • IT budget as a percentage of turnover • IT expenses per staff member
Sell to Third Parties
• financial benefits stemming from selling products and services
Business Value of the New IT Projects
• financial evaluation based on ROI, NPV, IRR, PB • business evaluation based on Information Economics
Business Value of the IT Function
• percentage of the development capacity engaged in strategic projects • relationship between new developments/infrastructure investments/replacement investments

Table 3 shows the specific variables for the subcomponent of User Orientation. The three proposed measures are: Preferred IT supplier, Partnership With Users, and User Satisfaction (Van Grembergen and Van Bruggen, 1998).

Table 3. Measures for User Orientation

Preferred IT Supplier
• % of applications managed by IT • % of applications delivered by IT • % of in-house applications
Partnership With Users
• index of user involvement in generating new strategic applications • index of user involvement in developing new applications • frequency of IT Steering Committee meetings
User Satisfaction
• index of user friendliness of applications • index of user satisfaction • index of availability of applications and systems • index of functionality of applications • % of application development and operations within the Service Level Agreement (SLA)

Table 4 shows the variables for Measures for Operational Excellence. The seven proposed measures are: Efficient Software Development, Efficient Operations, Acquisition PC's and PC Software, Problem Management, User Education, Managing IT Staff, and Use of Communications Software (Van Grembergen and Van Bruggen, 1998).

Table 4. Measures for Operational Excellence

Efficient Software Development
• % of changes and adjustments made throughout different development stages • number of defects per function point in the first year of production • number of function points per person-per month • average number of days late in delivering software • average unexpected budget increase • % of projects performed within SLA • % of code that is reused • % of maintenance activities • visible and invisible backlog
Efficient Operations
• % unavailability of the mainframe • % unavailability of the network • response times per category of users • % of jobs done within set times • % of reruns • average time between systems failures • ratio operational costs/installed MIPS
Acquisition PCs and PC Software
• average lead time for deliveries
Problem Management
• average answer time of help desk • % of questions answered with set time • % of solutions with SLA
User Education
• % of users that already received education (per technology/application) • quality index of education
Managing IT Staff
• number of people hours that can be charged internally or externally • % of people hours that are charged on projects • satisfaction index of IT staff
Use of Communications Software
• % of IT staff that can access groupware facilities (inter- and intranet) • % of IT staff that effectively use groupware facilities

Table 5 shows the variables for Measures for Future Orientation. The four proposed measures are: Permanent Education of Staff, Expertise of IT Staff,

Age of Applications Portfolio, and Research Into Emerging Technologies (Van Grembergen and Van Bruggen, 1998).

Table 5. Measures for Future Orientation

Permanent Education of Staff
• number of educational days per person • education budget as a % of total budget
Expertise of IT staff
• number of years of IT experience per staff member • age pyramid of the IT staff
Age of the Applications Portfolio
• number of applications per category • number of applications younger than five years
Research Into Emerging Technologies
• % of budget spent on IT research

The Federal Government has also contracted for and published three guides to improve the IT investment process. These publications are similar in nature and all provide general guidance for IT investment decisions. However, they cannot be considered models because of the very general nature of their scope. There are no brief sections that could be excerpted and used as a model to evaluate IT investment. Overall, the guides do provide an excellent overview of how to manage the IT investment process and are useful as an initiation point. The guides are as follows:

1. Air Force Information Technology Investment Performance Measurement Guide (ANDRULIS Corporation, 1997).

2. Assessing Risks and Returns: A Guide for Evaluating Federal Agencies IT Investment Decision Making (GAO, 1997).

3. Department of Defense Guide for Managing Information Technology as an Investment and Measuring Performance (Vector Research Incorporated, 1997).

Summary

There are many models that both academics and practitioners have examined in their search to adequately quantify IT investment. None of these models is universally accepted and the debate continues on how to analyze these investments. Public sector organizations also lack cash flows to use in the evaluation process. The models discussed are summarized in Table 6 below. Table 6 shows the equation number as listed in Chapter II, the Author's name, the name of the model, and the equation for the model.

Table 6. Summary of Models

Equation Number	Author	Name	Equation
1	Senn, Dos Santos	Net Present Value	$= - C_0 + \Sigma$ (t=1 to T) $A_t / (1+r)^t$
2	Senn	Payback	= total income / total time horizon
3	Kurnia and Swatman	Actual Costs	Total Costs - Total Benefits
4	Kurnia and Swatman	Actual Costs (Subsequent Years)	On-going Costs - On-going Benefits
5	Kumar, Dos Santos	Options	$V = B_1N(d_1)-C_1N(d_2)$
6	Hitt and Brynjolfsson	Consumer Surplus	$1/2 (S_{t+1} + S_t) * \log (p_t / p_{t+1}) * V$
7	Hitt and Brynjolfsson	Production Function	$V = \exp (\Sigma_t D_t + \Sigma_{j-1} D_j) C^{\beta 1} K^{\beta 2} L^{\beta 3}$

8	Hitt and Brynjolfsson	Profitability	$= \alpha_0 + \alpha_1$ * (ITRate) + control variables + ε
9	Strassmann	Cost of Information Management	= Cost of Sales, General and Administrative + Cost of Research and Development
10	Strassmann	Cost of Capital	= (Shareholder Equity + Capital Surplus) * Interest Rate
11	Strassmann	Information Productivity	Value Added by Information / Cost of Information Management
12	Strassmann	Value Added By Information	= Net Profit - (Financial Capital Assets * Interest Rate for Borrowing)
13	Strassmann	Information Productivity	Cost of Operations / Cost of Information Management
14	Strassmann	IT Spending	= a + b*(Cost of Sales, General, and Administrative) + c*Profits + D*Desktops + e*Professionals - f*Executives
15	Strassmann	Knowledge Capital	Management Value Added / Interest Rate for Equity Capital
16	Strassmann	Residual Value	= Change in Information Technology Assets = (equipment acquisition - equipment depreciation) + (development acquisition - development depreciation) + (software acquisition - software depreciation) + (training acquisition - training depreciation)
17	Strassmann	Knowledge Capital	Management Value Added / Price of Capital
18	Van Grembergen and Van Bruggen	Balanced Scorecard	See Table 1 through 5

III. Methodology

Introduction

This study is an exploratory investigation of the models currently in use or under development that may help answer the research questions. Before the research design is discussed at length, consider again the research questions.

1. What models are currently being used in the DoD and private industry to evaluate their investment in information technology?
2. Of these models, which ones can the Air Force use to evaluate potential investment in IT with regard to the availability of the required data?

Both qualitative and quantitative techniques are applicable although exploration relies more heavily on qualitative techniques (Cooper and Emory, 1995:118). The research design for this study is a qualitative technique.

Research Design

Criterion-based Congruence Analysis is a technique developed by Peifer to select, screen, and analyze qualitative data (Peifer, 1997:107). A graphical representation of this model is shown in Figure 1. This model is designed to use filters to select the objects to be analyzed. Embedded in the Criterion-based Congruence Analysis model is the work by Miles and Huberman (1994:12) and their view of qualitative analysis.

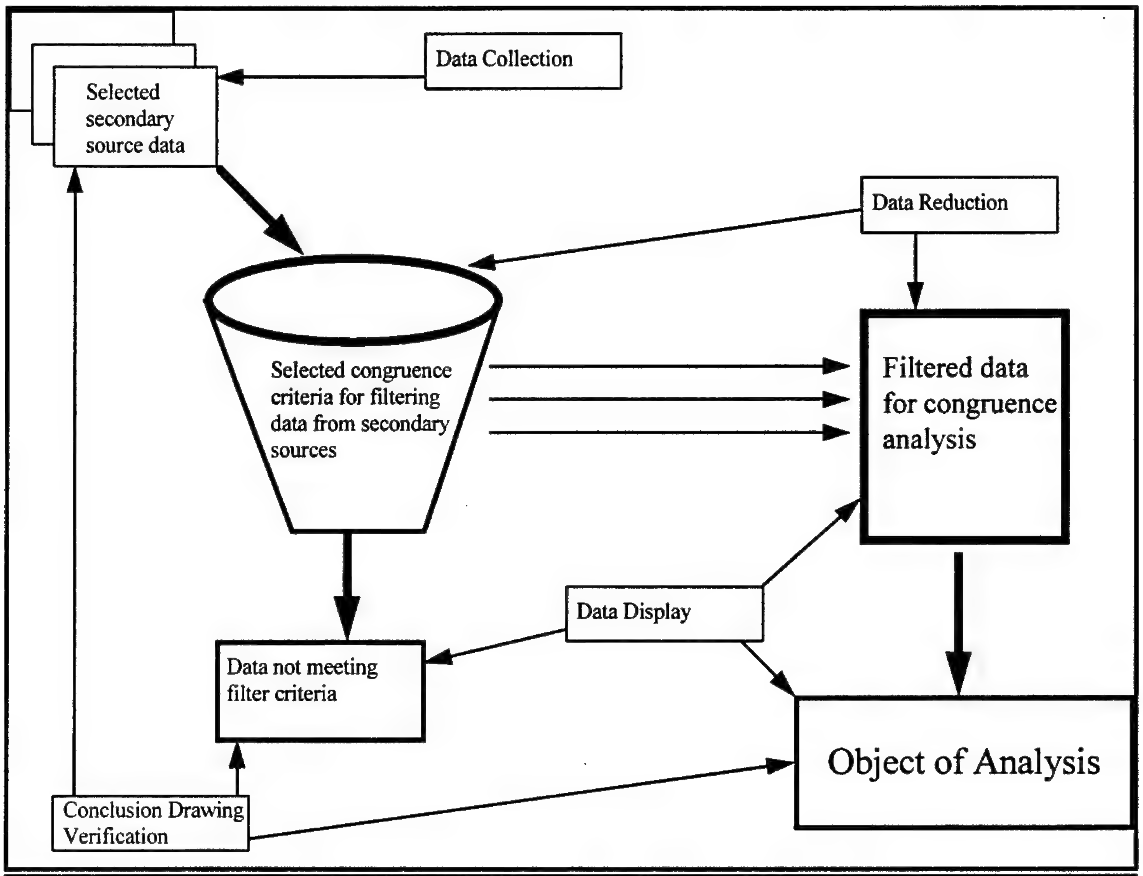

Figure 1. Criterion-Based Congruence Analysis (Peifer, 1997:111)

Miles and Huberman suggest a view of qualitative analysis based on four concepts: Data Collection, Data Reduction, Data Display and Conclusion Drawing/Verification. During the Criterion-based Congruence Analysis, all models were analyzed continuously. Miles and Huberman stated that "qualitative data analysis is a continuous, iterative enterprise" (Miles and Huberman, 1994:12). Miles and Huberman suggested the following technique for analysis: "Data analysis can be defined as three concurrent flows of activity;

data reduction, data display, and conclusion drawing/verification" (Miles and Huberman, 1994:12).

Figure 2 shows a graphical representation of the relationship between these four concepts as originally outlined.

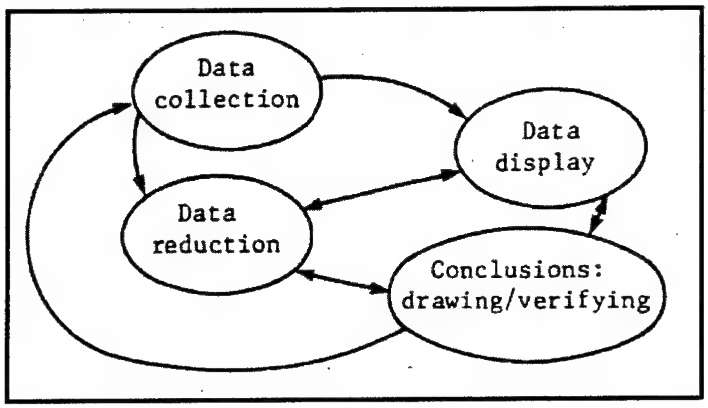

Figure 2. Quantitative Data Analysis (Miles and Huberman, 1994:12)

Next, the four concepts of qualitative analysis as described by Miles and Huberman and shown in Figure 2, are discussed in detail along with the specific techniques used to accomplish each task.

<u>Data Collection</u>

Data Collection occurs during a "sustained period" (Miles and Huberman, 1994:10) and allows continuous analysis of the qualitative data. For collection of data, Cooper and Emory described the technique of document analysis (Cooper

and Emory, 1995:119). This technique was used to discover what techniques practitioners and academia are currently using and prescribing.

Cooper and Emory stated that secondary data sources can be classified into external and internal sources (Cooper and Emory, 1995:241). For the purpose of this investigation, external sources are those outside the DoD or government. These data sources could come from almost anywhere. For example, this research will investigate sources from academia and private industry, and therefore opens up the research to sources such as academic and practitioner journals. The second type of secondary data source is internal sources. These sources are from entities within the federal government or the DoD and can be found at such sources as Defense Technical Information Center (DTIC) and on the internet at government sites.

There are many people involved in research to identify practical models for government and industry to properly evaluate their investment in information technology. These people can be classified into two categories: academia and practitioners. For the purpose of this research, consider practitioners as those people and organizations within the private sector of the economy whose work is based on maximizing efficiency or profits.

Literature from practitioners and academia are at the opposite ends of the spectrum with regard to how they share their information. First, literature from academia is readily available due to the nature of the researchers. For the researchers to get recognition, they must publish their models. However,

literature from practitioners is somewhat more difficult to obtain. If a company has models that it can use to be more efficient, it is unlikely the company will publicize these models so that their competitors could use them to increase their efficiency.

Government entities are somewhat different than academia and practitioners. Government entities are relatively open with their information. However, what makes that government different is the fact that there are organizations within government that could be classified as research based or practitioners. For instance, the Government Accounting Office (GAO) publishes many guides on efficiency and other topics, but does use them because of the nature of their work. The GAO is an overseer on government efficiency. There are also practitioners within government such as the DoD who will publish information on how to complete certain tasks. Often this information may be usable in other organizations. These organizations are in a similar situation to those in academia. It is beneficial for them to get recognized for their contributions to increasing government efficiency.

The goal of the search of external data sources is to identify any models that are relevant to the research question. The search was conducted in two specific domains: the facilities available from libraries and the internet. The search was limited to those publications in the information technology realm. An initial review of several economic and financial journals showed some articles

that addressed the topic, however, their models were still very much in the theoretical stages of development.

The two libraries searched are located at the Air Force Institute of Technology and Wright State University. The search mechanisms at the libraries were the Business Periodicals Guide and the electronic library search system called EBSCO from EBSCO Publishing (for results from EBSCO search, see Table 1).

EBSCO is a system that transitions from the standard library search to a computerized search focusing on academic and practitioner journals. It is a somewhat more narrowly focused system than the standard internet search engines. However, EBSCO is a computerized search system that follows the standard computerized search technique described below.

Cooper and Emory (1995:250), suggested the following outline for a computerized search:

1. Select an appropriate database. To initiate the data collection, the following meta search engines were examined: Yahoo, Alta Vista, and Hot Bot.
2. Type in the search terms. These search engines were used with the key words starting with "information technology" and limited by four additional words: investment, valuation, evaluation, and model. Advanced search techniques were used to limit the amount of hits. For example in all the search engines, it is possible to limit the results to sites that match all the key words by using the "and" or the "+" symbol. For example, the first search was initiated by the key

words “information and technology and investment.” The remaining searches were completed by changing “investment” to “valuation” to “evaluation” and finally to ”model.”

3. Examine the number of possible citations - expand or limit that number. As shown in Table 1, the search engines provided the number of citations stated in the second column. When examining the number of citations, it would appear from the numbers that the search engine that Hot Bot used is not as restrictive as the other three search engines when using the “and” criteria.

As stated earlier, every search was initiated with the two key words “information” and “technology.” Then the additional key words, shown in Table 7 below and discussed in paragraph 2 above, were added to limit the search. Table 7 shows in the search engine used, each key word added to “information” and “technology,” and the number of hits from each source.

Table 7. Results of Computerized Search Engines

Search Engine	Key Word	Number of Hits
Yahoo	evaluation	9
	investment	54
	valuation	4
	model	6
Alta Vista	evaluation	55
	investment	872
	valuation	125
	model	15
Hot Bot	evaluation	323,444
	investment	301,883
	valuation	260,090
	model	449,191
EBSCO	evaluation	55
	investment	90
	valuation	2
	model	37

One problem with these searches was the type of citations the search engines found. The overwhelming majority of the citations were references to consulting companies and referred mainly to the services they provided. The second largest category of citations was for college courses providing information on the course and in some cases the instructor. At this point a more narrowly focused search was required.

To accomplish this, web sites specifically relating to information technology were examined. These sites were found using keywords "information technology" followed by an investigation of the citations. In addition to the sites found in this search, sites from other sources were investigated. Due to the

nature of the Information Research Management academic program at AFIT, many sites addressing various topics relating to information technology have been discussed in class, and informally among the students. Table 8 is a listing of the specific IT sites examined that had content specifically relating to IT policy.

Table 8. Information Technology Internet Sites

Title	Web Address
CIO's Executive Research Center	http://www.cio.com/
Electronic College of Process Innovation	http://www.dtic.mil/c3i/bprcd/
IS Effectiveness	http://theweb.badm.sc.edu/grover/ isworld/
IS World	http://www.isworld.org/isworld.html
IT Policy OnRamp	http://www.itpolicy.gsa.gov/index.htm
Business Researchers Interests	http://www.brint.com/interest.html
Signal	http://www.us.net/signal/
Air Force Communications Agency	http://www.afca.scott.af.mil/pa/
Government Accounting Office	http://www.gao.gov
Air Force CIO	http://www.cio.hq.af.mil/
Navy	http://www.doncio.navy.mil/
Army	http://www.gordon.army.mil/

4. Retrieve an initial citation or citations. The meta search engines were adequately restricted by the use of the keywords. This allowed research of all hits on every site except Hot Bot where the combination keywords did not seem to filter the citations. The more specific sites listed in Table 8 were reviewed exhaustively to discover any models they may reference. Any link that remotely suggested a link to a model or discussion of models pertinent to this research was investigated.

5. Review the citations and decide if the search needs modification for additional, fewer or more precise citations. After the refined review in step four, the search needed no additional modification. Models were available to examine as a starting point for this research

6. Investigate the citations. The citations were reviewed and subjected to the following steps in the Criterion-based Congruence Analysis model.

Data Reduction

Data Reduction "refers to the process of selecting, focusing, simplifying, abstracting, and transforming the raw data that appear in written-up field notes" (Miles and Huberman, 1994:10). For this study, data reduction will focus on identifying and selecting models that may provide better information to DoD and government decision makers.

Model Filtering. The models will first be filtered based on their relevance to the problem. The key criteria for any model is relevance (Christ, 1966:4). For the model to have value for this research, it must address how the Air Force can better evaluate proposed IT investment as required by the ITMRA. Figure 3 shows different areas of IT evaluation where models may focus. By definition, this research is focused in the area of "Organizational Impact" (Delone and McLean, 1998).

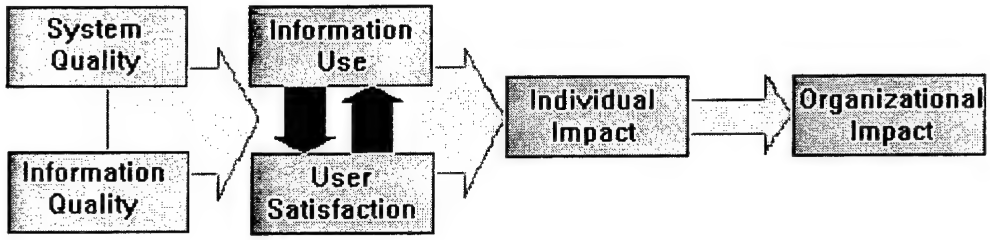

Figure 3. Computer System Effectiveness (Delone and McLean, 1998)

A Delphi panel, fully described below, was used to increase the validity of this research. In the final step, Conclusion Drawing and Verification, the Delphi panel's opinions on the relevance and availability of data for the variables used by the various models will be aggregated to evaluate the potential usefulness of the models for the Air Force.

The Delphi technique, "the name for a set of procedures for eliciting and refining the opinions of a group of people" (Dalkey, 1967:1), was used for data reduction and conclusion drawing in the Criterion-based Congruence Model. The Delphi technique is used because it offers "anonymity, controlled feedback and statistical group response" (Dalkey, 1967:3). This allows the participants to respond freely with no external forces to consider.

The researcher made an initial decision based on his experience in communications on whether or not the information described by each variable is available, not-available, collectable, or not collectable.

The Delphi panel was then asked to validate the researcher's conclusions based on their experience in the Air Force. To gather the Delphi group's

responses, a copy of Appendix A, Appendix B, and Table 10 were sent to each Major Command (MAJCOM) Communications Directorate. Table 9 shows the MAJCOMs that were offered the opportunity to participate in the Delphi panel. The first column is the list of MAJCOMs solicited and the second column shows whether or not the MAJCOM was able to respond.

Table 9. Major Command Participation

Major Command	Participated (Y / N)
ACC	Yes
AETC	No
AFMC	No
AFSOC	Yes
AMC	Yes
PACAF	No
SPACECOM	No
USAFE	Yes

Appendix A is the electronic mail cover letter. People were selected to form the Delphi panel based on the information provided in the instructions (Appendix A). The Delphi panel was asked to concur or non-concur with the researcher's initial conclusions. Appendix B is an extended definition of each variable. Table 10 is complete list of variables compromising the models.

Based on the responses from the Delphi panel, the models are filtered on the basis of whether or not the data to input into the variables is available, not available, collectable or not collectable. This matrix shows the variables in the first column with a brief definition. The next column, "available," is defined as whether the data is currently used for any other reason such as in quality indicators. The next column, "not-available," is for data that is not available for any reason. One example would be if a variable required a data point for "Profit." Government agencies are non-profit and do not collect this sort of data or generate profit. Some agencies are fee for service and therefore do generate revenue. For this reason, models requesting cash flows will not be discarded. The next column is "collectable." Collectable is defined as data that may not be currently used but could be relatively easily and inexpensively collected. The fourth column is "not-collectable." This column is for variables that would be too expensive or time consuming to obtain. This issue will not be discussed in this research due to its dynamic nature. Different organizations operate in diverse environments that may cause a variable that is collectable in one instance to be prohibitively expense to collect in another.

This results from the Delphi panel will be presented in Chapter IV in Table 11. This table shows what percentage of the Delphi panel concurred with the initial categorization of the variables. When there is disagreement among the Delphi panel about in which category the variable should be in, the percentage of the Delphi panel members that voted for each category is shown.

Table 10. Model Variables and Mapping

	Data Required					
	Variable	Available	Not-Available	Collectable	Not-Collectable	Maps to Model
1	B - expected return on asset		X			5,10,12
2	C - expected investment in asset	X				2,5
3	t - time to expiration of choice			X		5
4	ρ – correlation coefficient between return on asset and return investment in asset		X			5
5	σ – standard deviation of return on asset and return investment in asset		X			5
6	A - Cash flow at end of period		X			1,2
7	r - risk free rate of return			X		1,5,10,12
8	p - price of IT stock			X		6,7,8
9	V - value added				X	6,7
10	s - IT stock / value added				X	6
11	% above or within budget			X		18
12	allocation of different budget items			X		18
13	IT budget as a % of turnover				X	18
14	IT expenses per staff member			X		14,18
15	financial benefits from selling to third parties		X			18
16	financial evaluation based on ROI, NPV, IRR		X			1
17	% of business development capacity engaged in strategic projects		X			18
18	% of applications managed by IT			X		18
19	% of applications delivered by IT			X		18
20	% of in-house applications			X		18

Table 10. Model Variables and Mapping (continued)

	Variable	Available	Not-Available	Collectable	Not-Collectable	Maps to Model
21	frequency of IT Steering Committee Meetings	X				18
22	% of application development and operations within the SLA			X		18
23	% of changes and adjustments made throughout different development stages			X		18
24	number of defects per function point in first year of production			X		18
25	number of function points per person per month			X		18
26	average number of days late in delivering software			X		18
27	average unexpected budget increase			X		18
28	% of projects performed within SLA			X		18
29	% of code reused			X		18
30	% of maintenance activities			X		18
31	% unavailability of mainframe	X				18
32	% unavailability of the network	X				18
33	response times per category of users				X	18
34	% of jobs completed within set times			X		18
35	% of reruns				X	18
36	average time between systems failures	X				18
37	ratio of operational costs to installed MIPS				X	18
38	average lead time for deliveries			X		18
39	average answer time of help desk				X	18
40	% of questions answered within set time			X		18

Table 10. Model Variables and Mapping (continued)

	Variable	Available	Not-Available	Collectable	Not-Collectable	Maps to Model
41	% of solutions within SLA			X		18
42	% of users that already received education per technology/application			X		18
43	quality index of education			X		18
44	number of hours that can be charged internally or externally				X	18
45	% of people hours charged on projects				X	18
46	satisfaction index of IT staff			X		16,18
47	% of IT staff that can access groupware facilities			X		18
48	% of IT staff that can effectively use groupware facilities			X		18
49	number of education days per person			X		18
50	education budget as a percentage of IT budget			X		18
51	number of years experience per staff member			X		18
52	age pyramid of IT staff			X		18
53	number of applications per age category			X		18
54	number of applications younger than 5 years			X		18
55	% of budget spent on IT research			X		18
56	hardware costs	X				1,2,3,4,13,16
57	software costs	X				1,2,3,4,13,17
58	transmission costs				X	1,2,3,4,13,18
59	processing costs savings				X	2,3,4
60	paper savings				X	2,3,5
61	inventory savings		X			2,3,6
62	quantifiable intangible benefits				X	2,3,4,13
63	software maintenance costs	X				1,2,3,4
64	fixed annual costs			X		1,2,3,4,13

Table 10. Model Variables and Mapping (continued)

	Variable	Available	Not-Available	Collectable	Not-Collectable	Maps to Model
65	Cost of Sales, General and Administrative		X			9,14
66	Cost of Research and Development				X	9,10
67	Shareholder Equity		X			10
68	Capital Surplus		X			10
69	Management Value Added		X			17
70	Costs of Management				X	
71	Costs of Information Management				X	13
72	Value Added by Information		X			11
73	Information Productivity		X			16
74	Equipment Depreciation			X		16
75	Development Depreciation		X			16
76	Software Depreciation			X		16
77	Training Depreciation			X		16

Data Display

Data Display is defined "as an organized assembly of information that permits conclusion drawing and action taking" (Miles and Huberman, 1994:11). After the models are identified as possibly being useful in some situation (naturally not all models will be useful in all circumstances). Many of these models took dramatically different approaches to examining IT investment and focused on different areas. Remember that the focus of this study is to discover models and review their usefulness.

The data display exists in Chapter IV. Chapter II describes the models and the variables they require. This information is summarized in a matrix format

for ease of viewing and evaluating. "The most frequent form of display for qualitative data in the past has been extended text" (Miles and Huberman, 1994:11). However, Miles and Huberman later state this type of display "is dispersed, sequential rather than simultaneous, poorly structured, and extremely bulky" (Miles and Huberman, 1994:11). To alleviate this problem a matrix structure consisting of the identified variables in columns and the filters in rows will be used. The variables are separated from the models to allow independent review of the variable without any bias towards what problem the model may address. This matrix is designed to demonstrate why any variable and eventually any model was filtered.

Conclusion Drawing and Verification

Conclusion Drawing and Verification "is beginning to decide what things mean, is noting regularities, patterns, explanations, possible configurations, causal flows, and propositions" (Miles and Huberman, 1994:11). The basis for the conclusions is the results of the Delphi panel in Chapter IV. Models that do not have a majority opinion from the Delphi panel that the required variables are available or collectable will be classified as not currently useful for the Air Force. The final conclusions based on this filtering will be fully discussed in Chapter V.

An important part of research is understanding what you have "not" done in addition to what you have. Any gaps that this research uncovers will be

discussed at length in Chapter V where recommendations for future research are made.

Summary

This is an exploratory study designed to select, screen, and analyze models that will improve the Air Force's IT investment decision process. For this, the Criterion-based Congruence Model was chosen for its structured approach and its combination of previously recognized techniques such as those prescribed by Miles and Huberman, and Cooper and Emory. A Delphi panel then validated the researcher's initial conclusions based on their experience in Air Force communications.

IV. Analysis

Results

This chapter will describe the results of the Criterion-Based Congruence Analysis model described in Chapter III. Chapter I stated the research objectives as follows:

1. Identify possible IT investment evaluation models
2. Identify which models meet the intent of the ITMRA
3. Identify which models are feasible for the Air Force

These objectives were met by specific parts of the Criterion-Based Congruence Analysis and are discussed in order. IT investment evaluation models discovered during the data collection stage were summarized in Table 6 in Chapter II.

Section 5122 (b) 5 tasked government agencies to "provide for identifying for a proposed investment quantifiable measures for determining the net benefits and risks of the investment" (United States Congress, Sec 5122 (b) 5). The models all meet the intent of this law. Each model uses quantifiable measures to examine the benefits and risks of proposed IT investment.

The models examine, in a variety of ways, the costs and benefits of IT investment. Quantifying the risks of an investment is a somewhat more abstract idea. However, by efficiently evaluating the costs and benefits of a proposed IT investment, the Air Force is reducing the risk of the purchase. Scenario analysis

and sensitivity analysis are two of the key principles of risk management (Cooley and Roden, 1988:400). Scenario analysis is defined as "analysis of a capital project's profitability under three sets of assumptions: pessimistic, most likely, and optimistic" (Cooley and Roden, 1988:383). Scenario analysis is defined as "analysis of the effects that key input variables, changed one at a time, have on the profitability of a capital investment" (Cooley and Roden, 1988:5). Many of the models do not have profitability as a specific objective, however, the objective of the model can be analyzed using the same principles of scenario and sensitivity analysis. By using models that require specific identification of variables, the Air Force has the basic information required to complete the required risk analysis.

For models to be useful to the Air Force, the required variables must be available. Table 11 is a copy of Table 10 with the exception of the final column. The final column, Delphi, shows whether the members of the panel concurred or non-concurred with the researcher's initial classification of the variables. In the event of non-concurrence, the percentage of members of the Delphi panel voting for each category is shown.

Table 11. Delphi Panel Results

	Data Required					Delphi
	Variable	Available	Not-Available	Collectable	Not-Collectable	Concur / Non-concur
1	B - expected return on asset		X	50%		non-concur
2	C - expected investment in asset	X				concur
3	t - time to expiration of choice	25%		X		non-concur
4	ρ – correlation coefficient between return on asset and return investment in asset		X	25%		non-concur
5	σ – standard deviation of return on asset and return investment in asset		X			concur
6	A - Cash flow at end of period		X			concur
7	r - risk free rate of return			X		concur
8	p - price of IT stock			X		concur
9	V - value added				X	concur
10	s - IT stock / value added				X	concur
11	% above or within budget	25%		X		non-concur
12	allocation of different budget items	25%		X		non-concur
13	IT budget as a % of turnover			25%	X	non-concur
14	IT expenses per staff member			X		concur
15	financial benefits from selling to third parties		X	25%		nonconcur
16	financial evaluation based on ROI, NPV, IRR		X	50%		nonconcur
17	% of business development capacity engaged in strategic projects		X	50%		nonconcur
18	% of applications managed by IT			X		concur
19	% of applications delivered by IT			X		concur
20	% of in-house applications			X		concur

Table 10. Delphi Panel Results (continued)

	Variable	Available	Not-Available	Collectable	Not-Collectable	Concur / Non-concur
21	frequency of IT Steering Committee Meetings	X		25%		non-concur
22	% of application development and operations within the SLA			X		concur
23	% of changes and adjustments made throughout different development stages			X		concur
24	number of defects per function point in first year of production			X	25%	non-concur
25	number of function points per person per month			X		concur
26	average number of days late in delivering software			X		concur
27	average unexpected budget increase		25%	X		non-concur
28	% of projects performed within SLA			X		concur
29	% of code reused			X		concur
30	% of maintenance activities			X		concur
31	% unavailability of mainframe	X		25%		non-concur
32	% unavailability of the network	X		25%		non-concur
33	response times per category of users			25%	X	non-concur
34	% of jobs completed within set times			X		concur
35	% of reruns			25%	X	non-concur
36	average time between systems failures	X		25%		non-concur
37	ratio of operational costs to installed MIPS			25%	X	non-concur
38	average lead time for deliveries			X		concur
39	average answer time of help desk	25%		25%	X	non-concur
40	% of questions answered within set time	25%		X		non-concur

Table 10. Delphi Panel Results (continued)

	Variable	Available	Not-Available	Collectable	Not-Collectable	Concur / Non-concur
41	% of solutions within SLA	25%		X		non-concur
42	% of users that already received education per technology/application			X		concur
43	quality index of education			X		concur
44	number of hours that can be charged internally or externally			25%	X	non-concur
45	% of people hours charged on projects			25%	X	non-concur
46	satisfaction index of IT staff			X		concur
47	% of IT staff that can access groupware facilities			X		concur
48	% of IT staff that can effectively use groupware facilities			X		concur
49	number of education days per person			X		concur
50	education budget as a percentage of IT budget	25%		X		non-concur
51	number of years experience per staff member			X		concur
52	age pyramid of IT staff			X		concur
53	number of applications per age category			X		concur
54	number of applications younger than 5 years			X		concur
55	% of budget spent on IT research		25%	X		non-concur
56	hardware costs	X		25%		non-concur
57	software costs	X		25%		non-concur
58	transmission costs	25%		50%	X	non-concur
59	processing costs savings			25%	X	non-concur
60	paper savings	25%		25%	X	non-concur
61	inventory savings		X	25%		non-concur
62	quantifiable intangible benefits			25%	X	non-concur
63	software maintenance costs	X		25%		non-concur
64	fixed annual costs	25%		X		non-concur

Table 10. Delphi Panel Results (continued)

	Variable	Available	Not-Available	Collectable	Not-Collectable	Concur / Non-concur
65	Cost of Sales, General and Administrative	25%	X	25%	25%	nonconcur
66	Cost of Research and Development				X	concur
67	Shareholder Equity		X			concur
68	Capital Surplus		X			concur
69	Management Value Added		X			concur
70	Costs of Management			25%	X	non-concur
71	Costs of Information Management			75%	X	non-concur
72	Value Added by Information		X	25%		non-concur
73	Information Productivity		X			concur
74	Equipment Depreciation			X		concur
75	Development Depreciation		X	25%		non-concur
76	Software Depreciation		25%	X		non-concur
77	Training Depreciation		25%	X		non-concur

Findings

If any model is purely equation based and cannot be used without all relevant variables, it is not valid for Air Force use at this point in time. For example, if a model used a variable in multiplication or division and the variable was not available or not collectable, the whole model could not be used. However, in addition and subtraction models, all variables need not be available or collectable. In this type of model, the variable can be reduced to zero and will not effect the other terms in the model. There may be changes in the future that may change this initial conclusion. For example, if an organization went completely fee for service or had a system that was dedicated to fee for service operations, a model that is not currently valid may be useful to set prices or

make decisions among systems. Following is a discussion of the results of the Delphi panel with regard to each model.

The NPV model (equation 1) currently has limited value for the Air Force. The Delphi panel unanimously concurred that Variable 6, cash flow at end of period, was not available. This variable is critical for use of this model.

The Payback model (equation 2) suffers from the same limitations as the NPV model. This model requires a cash flow, Variable 6, to compute the length of time until the initial investment is returned.

The Cost-Benefit Analysis (equation 3 and 4) is the first model that may be useful for the Air Force. There was significant non-concurrence from the Delphi panel on the collectability and availability of the variables. The researcher initially concluded that Variables 58-60 and 61 were not-collectable. However, the majority of the Delphi panel disagreed and concluded that these variables were in fact collectable or already available. Remember, this model was developed specifically with regard to the public sector (Kurnia and Swatman, 1997:5).

The Options model (equation 5) has also shows limited usefulness for the Air Force at the present time. The Delphi panel unanimously concurred that Variable 5, standard deviation of return on asset and investment in asset, was not available. This model also had mixed results regarding Variable 1, expected return on asset, and Variable 4, correlation coefficient. Fifty percent and

seventy-five percent respectively, of the Delphi panel concurred that these variables are not available.

The Consumer Surplus model (equation 6) is not useful for the Air Force at the present time because of Variable 9, Value Added (mapped from output elasticity, β). The Delphi panel unanimously concurred that Variable 9 is not collectable.

The Production Function model (equation 7) is not useful to the Air Force. The Delphi panel unanimously concurred that Variable 9, Value Added, was not collectable.

The Profitability model (equation 8) may be useful for the Air Force in very specific circumstances. The Delphi panel agreed that Variable 8 is collectable. However, this model requires constants based on other factors to predict profitability. In situations where the system is to be used on a fee for service situation, the model may be useful to estimate a price high enough to cover the costs described by Variable 8, Price of IT Stock.

The Cost of Information Management model (equation 9) also had mixed results within the panel. The Delphi panel was split on Variable 65, Cost of Sales, General, and Administrative. Fifty percent of the panel voted that Variable 65 was available or collectable and fifty percent voted that the variable was not available or not collectable. The second variable in this equation was Variable 66, Cost of Research and Development. The Delphi panel unanimously

agreed that this variable was not collectable. However, if this variable was set a zero, it would not make the model invalid.

The Cost of Capital model (equation 10) is not useful to the Air Force. This model requires measures of Variable 67, Shareholder Equity, and Variable 68, Capital Surplus, that the Delphi panel unanimously concurred were not available.

The Information Productivity model (equation 11) is based on other models in this research. This model is the result of equation 12 divided by equation 9. While the results of the Delphi panel on equation 9 were mixed, on equation 12 they were not. As described in the next paragraph, equation 12 is not useful due to its requirement for net-profit.

The Value Added by Information (equation 12) model is not useful to the Air Force. This model includes Variable 6, Cash flow, which the Delphi panel unanimously concurred was not collectable.

The Information Productivity, Public Sector model (equation 13) is dependent on equation 9, the Cost of Information Management. If an organization can use equation 9, then it also will be able to use this model as another measure.

The IT Spending model (equation 14) is currently useful to the Air Force in certain situations. This model is designed to compare IT spending among organizations and could be used to quantify how well lower level organizations are using their IT budget. The one variable that is not available Variable 6, Cash

flow, (which ultimately could be reduced to profits) could be reduced to zero and have no net effect on the value when used to compare similar organizations.

The Knowledge Capital model (equation 15) is not currently useful to the Air Force. This model relies on a value from equation 12, which the Delphi panel unanimously concurred was not available.

The Residual Value model (equation 16) may be useful to the Air Force in certain situations. A majority of the Delphi panel determined that Variable 76, Software Depreciation, and Variable 77, training Depreciation, was available. A majority of the Delphi panel concurred that Variable 75, Development Depreciation, was not available. However, as in the IT spending model (equation 14), if this variable were reduced to zero, there would be no effect when comparing similar organizations. This model could be used (similarly to equation 14) to compare management practices among similar organizations within the Air Force.

The Knowledge Capital model (equation 17) is not currently useful for the Air Force. This model also relies on input from equation 12, which is not available.

The final model, the Balanced Scorecard (model 18) is slightly different from the other models. Instead of looking at quantifiable measures and using them in an equation to generate a specific number, the Balanced Scorecard seeks to use quantifiable measures to judge how an organization is meeting it goals. Of the 44 variables in the Balanced Scorecard (variables 11-55), the vast

majority of the variables were either available or collectable. A majority of the Delphi panel concluded that Variable 15, Financial Benefits of Selling to Third Parties, was not available. Variable 33, Response Times per Category of Users, Variable 35, Percentage of Reruns, Variable 37, Ratio of Operational Costs to Installed MIPS, Variable 44, Number of Hours that can be Charged Internally or Externally, and Variable 45, Percentage of People Hours Charged on Projects, all received a majority of Delphi panel concurrence that they were not collectable. If these six variables were not used, the Balanced Scorecard would still have 38 variables that could be used to measure an organization's performance in relation to specific goals or in relation to another organization.

Table 12 is a summary of the discussion of the usefulness of the models. The first column is the equation number from Chapter II. The second column is the name of the equation. The third and fourth columns represent whether or not the data is available or collectable and whether or not the data is not available or not collectable.

Table 12. Summary of Models

Equation Number	Equation Name	Available / Collectable	Not-Available / Not-Collectable
1	Net Present Value		X
2	Payback		X
3	Actual Costs (First Year)	X	
4	Actual Costs (Subsequent Years)	X	
5	Options		X
6	Consumer Surplus		X
7	Production Function		X
8	Buiness Profitability	X	
9	Cost of Information Management	X	
10	Cost of Captial		X
11	Information Productivity (Private Sector)		X
12	Value Added By Information		X
13	Information Productivity (Public Sector)	X, dependant on Equation 9	
14	IT Spending	X	
15	Knowledge Capital		X
16	Residual Value	X	
17	Knowledge Capital (Revised)		X
18	Balanced Scorecard	X	

V. Conclusions

Overview

The ITMRA has tasked government organizations to develop and use quantitative methods to evaluate potential IT investment decisions. This research set out with the objective of discovering what IT investment evaluation models were currently in use both in public or private sector organizations. The second objective was to identify those models which met the intent of the ITMRA, specifically to "identify net benefits and risks of proposed investments" (United States Congress, 1996: Section 5122 (b) 5). The final objective was to determine which of those models were feasible for Air Force use.

A total of 18 models were found ranging from basic accounting models to more theoretical econometric models. The full list of these models is shown is Table 6 in Chapter II. These models had a total of 77 variables, many of which were common to several models. The complete variable list is shown in Table 10 in Chapter III.

The Delphi panel then screened the variables to determine which models were usable given the information required for the variables composing a specific model. This research suggests that there are models available that may improve the Air Force's decision making process in the area of IT investment.

Conclusions

There are five models that may help the Air Force better manage the benefits and risks of IT investment: Cost Benefit Analysis, Residual Value, IT Spending, Cost of Information Management, and the Balanced Scorecard. In addition, two other models may be useful in certain situations. The Business Profitability and Information Productivity models use data that may be collectable in certain organizations

The Cost Benefit Analysis model shows how the Air Force can examine an IT investment in terms of initial investment and subsequent management. The one possible problem with this model is the variable "Quantifiable Intangible Benefits." As stated earlier in the literature review, intangible benefits of IT are often the most important (Senn, 1978:525). The costs, which are significantly easier to quantify, may outweigh the benefits of many systems if the organization is not able to fully quantify the intangible benefits.

Three of Strassmann's models may also be useful for the Air Force. The Residual Value, IT Spending, and Cost of Information Management models all provide a means to evaluate how well organizations are managing IT investment.

The Residual Value and IT Spending models both provide insight into how well an organization manages its IT investment. The Delphi panel concurred that the majority of the variables required by these two models are either available or collectable.

One problem could develop with successful utilization of the Cost of Information Management model. This model is dependent on the variable Cost of Sales, General, and Administrative, and the variable Cost of Research and Development. The Delphi panel was somewhat mixed in the availability or collectability of the Cost of Sales, General, and Administrative. The Delphi panel was unanimous that the Cost of Research and Development was not-collectable. This model requires more study before its usefulness can be fully determined.

The final model that may prove useful to the Air Force is the Balanced Scorecard. This model is designed to use quantifiable variables to track how well an organization meets certain strategic goals. While the total value of an IT investment is not quantified, the model does provide a complete framework for managing IT investment. This may well be where the Air Force needs to focus. In his book The Squandered Computer, Strassmann stated "alignment is the delivery of required results" (Strassmann, 1997:3). This could be how the Air Force could best focus its IT investment. Through the use of the Residual Value and IT Spending models, the Air Force may be able to track best practices among its organizations and develop specific benchmarks for relative amounts of IT spending. While it may take time to initiate a system to accomplish this, it may be a move in the right direction.

Overall, the Balanced Scorecard, Residual Value and IT Spending models may contribute to more efficient management of IT investment. While they do not specifically quantify the value of an IT investment, they do focus on

alignment with strategic goals. Proper alignment with strategic goals can serve to reduce the risks of these investments. One could argue that in the public sector, where organizations cannot track income against specific IT investment, that strategic alignment is where government should focus.

Table 13 summarizes the models that are useable for the Air Force. The first five models use variables that are available or collectable. The last two models use variables that may be relevant to specific Air Force organizations.

Table 13. Usable Models

Equation Number	Name
3 and 4	Cost Benefit Analysis
9	Cost of Information Management
14	IT Spending
16	Residual Value
18	Balanced Scorecard
8	Business Profitability
13	Information Productivity

Limitations and Implications

The search for models currently in use was based on models that have been published in recognized journals and texts. The majority of these models have not been thoroughly tested and therefore will face some obstacles before widespread use in the Air Force.

There are two important implications for the Air Force that developed from this study. First, there are models which are useful immediately to improve the

Air Force's IT investment process. However, of the models that showed promise, there is still work to be done before they are accepted by a significant number of the decision makers. The most promising models which are those that have some subjective measures embedded in them and present results related to how we can better manage the risks of the IT investment process and focus on strategic alignment.

Areas for Future Research

The primary area for future research is to test the models in real world situations and judge them on the basis of how they contribute to the IT investment decision process. This would involve extensive coordination with an agency that would allow the researcher extended access to its records and processes.

Another area where future research could improve this situation would be to try to improve certain models so that they are more useful to the Air Force. Many of the models are unusable now because of one or two variables. There is certainly the possibility that these models could be refined to more specifically address the needs of the public sector. As with testing models, this research would require extensive coordination between the researcher and an agency to see exactly what variables are available and could be exchanged to make a model more useful and relevant to the IT investment process in the public sector.

Appendix A: Delphi Panel Electronic Mail Cover Letter

Dear (individual's name) 28 July 98

1. I am a graduate student at the Air Force Institute of Technology conducting research into how the Air Force evaluates its investment in information technology. As you know, the Information Technology Management Reform Act (Clinger-Cohen Act) requires the government to improve its investment decisions for proposed investment in information technology. I am investigating what models are currently used in both the public and private sector to evaluate information technology investments and the possible usefulness of these models in the Air Force.

2. I request your help to choose someone on the MAJCOM staff (who should remain anonymous to me) who has some experience in the area of information technology investment planning to review the data that the models require and concur or nonconcur with my judgment on the availability or collectability of these variables. There are two attached files with this email. The first, (varlist.doc) is the instructions and an expanded variable list. The second attached file (varlist.xls) shows the list of variables required by the models in a matrix form.

3. After the review of the variables at the MAJCOM level, please forward varlist.xls back to me by 7 August 98. There will be no attribution of any feedback from any MAJCOM. The numbers will be reported only as a percentage of the respondents that agreed with the variable validation.

4. I may be reached at 937-426-3328 or at tpeachey@afit.af.mil. My thesis advisor is Major Bill Scott who may be contacted at DSN 785-7777 ext. 3323, or at wscott@afit.af.mil.

5. At your request, a copy of this thesis will be sent to you by electronic mail on completion.

Thanks for your help in this research.

TODD A. PEACHEY, Captain, USAF
Graduate Student, Air Force Institute of Technology

Instructions for Completion of Variable Validation

1. Each of these variables is part of a model that is currently used or proposed as a technique to evaluate information technology. For these models to be useful for the Air Force, we must have the data or at least be able to collect it to use the model.

2. This survey is not designed for you to have to complete any research on whether or not your unit collects this data. The answers are to be based solely on your opinions and previous experiences as an Air Force Communications Officer. There will be NO attribution of these opinions to any unit or person. The only information that will be reported is the percentage of responses in each category. The basis of this research is simply to find a model that helps us better evaluate our IT investments, not make any statements about what we may or may not have done in the past.

3. The variable descriptions listed in the left hand column are used in different models to evaluate information technology. Any symbols in the box are notation from the model. A more detailed description of each variable is available in the next section of the instructions.

3. The next column of the sheet is "Available." This box should be checked if the data is currently collected by organizations.

4. The next column of the sheet is "Not-Available." This box should be checked if the data does not apply to any organizations in the Air Force that you are aware of.

5. The next column of the sheet is "Collectable." This column should be checked if the data could be collected in a reasonable time frame and for a reasonable cost.

6. The next column of the sheet is "Not- Collectable." This column should be checked if collection of the data would require too much time and expense to justify its use.

7. Place a "c" or "n" in the final column to represent concurrence or nonconcurrence. If an "n" is placed in the box, place another mark, other than "x" in the box you feel is most appropriate (i.e. Available, Not-Available, Collectable, Not-Collectable)

Appendix B. Extended Variable Definitions

1. expected return on asset - the expected monetary return that an asset generates, that is, the cash flow that the asset generates divided by the asset's cost

2. expected investment in asset - initial cost of asset

3. time to expiration of choice - used when considering two or more investments, this is the time between now and when the latest information technology investment could be made

4. correlation coefficient between return on asset and investment in asset - numerical description of how return on asset relates to investment in asset, that is, a positive one would imply return on asset increases at the exact same percentage rate as the cost of the asset

5. standard deviation of return on asset and investment in asset - amount of variability between return on asset and investment in asset

6. cash flow at end of period - last cash inflow in a specific time period that an asset generates

7. risk free rate of return - rate that government borrows money for

8. price of IT stock - total investment in computer equipment plus three times the amount of labor necessary to operate it

9. value added - any measure of output (sales, production, etc.) minus total firm non-labor expenses

10. IT stock / value added - price of IT stock divided by value added

11. % above or within budget - actual expenses divided by budgeted expenses

12. allocation different budget items - amount of budget items that can be allocated to different expense accounts or user accounts

13. IT budget as a % of turnover - new IT purchases divided by total IT assets

14. IT expenses per staff member - total IT expenses divided by total number of staff members, that is administrative personnel not actively involved in IT operations

15. financial benefits from selling to third parties - incoming cash flows generated from selling IT capability to customers outside the unit

16. financial evaluation based on Return On Investment, Net Present Value, Internal Rate Return - data such as incoming cash flows from the IT asset and the risk-free interest rate

17. % of business development capacity engaged in strategic projects - amount of money and personnel hours from the IT department dedicated to strategic projects divided by total money and personnel hours of the IT department

18. % of applications managed by IT - number of applications (MS Office, PC3, etc.) software managed by IT personnel divided by total number of applications

19. % of applications delivered by IT - amount of application software purchased and installed by IT department divided by total amount of applications

20. % of in-house applications - amount of in-house applications developed by IT department divided by total amount of IT applications

21. frequency of IT Steering Committee Meetings - number of meetings per month, quarter, or year

22. % of application development and operations within a Service Level Agreement (SLA) - amount of application development and operations provided to users through SLA

23. % of changes and adjustments made throughout different development stages - number of changes and adjustments (software development) in each stage divided by total number of adjustments and changes

24. number of defects per function point in first year of production - refers to software development

25. number of function points per person per month - refers to software development

26. average number of days late in delivering software - software development for users

27. average unexpected budget increases - refers to software development

28. % of projects performed within SLA - number of projects performed within SLA divided by total number of projects

29. % of code reused - refers to software development

30. % of maintenance activities - refers to software development, maintenance of software currently in use

31. % unavailability of mainframe - mainframe downtime for users

32. % unavailability of network - network downtime for users

33. response times per category of users - response times from mainframe and network

34. % of jobs completed within set times - jobs by users on mainframe completed within set times divided by total number of jobs by users

35. % of reruns - number of reruns of jobs by users divided by total number of jobs by users

36. average time between systems failures - mainframe or network

37. ratio of operational costs to installed MIPS - operations costs of mainframe computer divided by total MIPS (or network divided by throughput)

38. average lead time for deliveries - deliveries on purchase of software and hardware purchased from outside vendors

39. average answer time of help desk - network or other computer related help desks within the unit

40. % of questions answered within set time - number of questions to help desk answered within set time divided by total number of questions

41. % of solutions within SLA - number of solutions to help desk problems within SLA divided by total number of help desk solutions

42. % of users that already received education per application / technology - number of users that have received training in particular application / technology divided by total number of users of the application / technology

43. quality index of education - subjective measurement tool designed to assess quality of training

44. number of hours that can be charged internally or externally - number of hours of IT staff work that can be charged to specific users (maintenance and other tasks)

45. % of people hours charged on projects - people hours that can be charged to specific projects

46. satisfaction index of IT staffs - measurement tool designed to assess IT staff satisfaction with their job

47. % of IT staff that can access groupware facilities - number of IT staff that can access groupware facilities divided by total number of IT staff

48. % of IT staff that can effectively use groupware facilities - number of IT staff trained in use of groupware facilities divided by total number of IT staff

49. number of education days per person - number of training days per IT staff member

50. education budget as a % of IT budget - education budget in dollars divided by total IT budget in dollars

51. number of years experience per IT staff member - specific number of years experience of each IT staff member used to compute average IT staff experience

52. age pyramid of IT staff - age data on IT staff used to measure IT staff experience

53. number of applications per age category - age of application software ranked into specific categories

54. number of applications younger than five years - age of software

55. % of budget spent on IT research - IT budget dollars spent on research divided by total IT budget

56. hardware costs - total costs of hardware including purchase, installation, maintenance, etc.

57. software costs - total costs of software including purchase, installation, maintenance, etc.

58. transmission costs - total costs of connectivity including purchase, installation, maintenance, etc.

59. processing costs savings- total costs associated with faster processing associated with a new system

60. paper savings - reduced costs from new systems

61. inventory savings - savings from reduced inventory due specifically to new system

62. quantifiable intangible benefits - any benefit from a new system that is quantifiable

63. software maintenance costs - any cost related to software maintenance

64. fixed annual costs of new system - any cost that can be traced to the new system on an annualized basis

65. cost of sales, general and administrative - all costs traceable to sales and administrative functions

66. cost of research and development - all costs traceable to an organization's research and development efforts

67. shareholder equity - standard ownership of corporations

68. capital surplus - excess capital after dividends paid to shareholders

69. management value added - funds left over after all costs are accounted for

70. costs of management - expenses not traceable to operations activities

71. costs of information management - costs traceable to information management activities

72. value added by information - net profit minus financial capital assets times risk free interest rate

73. information productivity - value added by information divided by cost of information management (variable 72 / variable 71)

74. equipment depreciation - loss in value of equipment (computers, routers, etc.) through use and advancement of technology

75. development depreciation - loss in value of equipment, software, etc. through use or advancement of technology (refers to in-house development)

76. software depreciation - loss in value of software due to technology advancement

77. training depreciation - loss in value of training due to new equipment, software, turnover of personnel etc.

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Vita

Captain Todd A. Peachey was born 20 December 1963 in Lewistown, Pennsylvania. He graduated from Kishacoquillas High School in Reedsville, Pennsylvania and Penn State University where he majored in Finance.

After graduation, he was selected for Officer Training School at Maxwell Air Force Base, Alabama. Upon commissioning, he was selected for Basic Communications Officer Training (BCOT) at Keesler Air Force Base, Mississippi. While at BCOT, he was selected for the Armed Forces Communications Electronics Award. After graduation, he was assigned to the 12th Flying Training Wing, Randolph Air Force Base, Texas.

While at Randolph Air Force Base, he initially served as the Deputy Flight Commander, Mission Systems Flight. After 18 months in this position, he served as the Executive Officer for the Squadron Commander.

He entered the Information Resource Management program at the Graduate School of Logistics and Acquisition Management at the Air Force Institute of Technology in March 1997.

Permanent Address: 62 Seneca Drive
Belleville, PA 17004

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13. ABSTRACT (*Maximum 200 Words*)

Information technology investment has become a significant part of the Department of Defense's budget. The Information Technology Management Reform Act requires that government quantitatively evaluate future information technology investments. Quantitative evaluation of IT investments present special problems for agencies that do not generate incoming cash flows. This thesis is designed to examine models that are currently being used in the public and private sector of the economy to evaluate Information Technology investments to learn which ones might serve the needs of the United States Air Force. The methodology is an exploratory study based on Criterion-based Congruence Analysis. This technique is designed to collect information and then filter it to surface the information that is pertinent to the research question. This research uncovered 18 models that use a variety of methods to value information technology. Of these models, five could currently be used by the Air Force based on the availability of the required data. These models are: Cost Benefit Analysis, Cost of Information Management, IT Spending, Residual Value, and the Balanced Scorecard. There are two additional models that may contribute to investment decisions in very specific circumstances. These models are: Business Profitability, and Information Productivity.

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